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ABSTRACT

This publication summarizes the main findings of the fourth Assessment of Achievement Programme (AAP) survey of students' attainment in science in Scotland in 1996. The main AAP objectives are to describe national levels of attainment and to provide evidence of changes in these levels over time. Assessment tasks were used with a representative sample of students at three stages: Primary 4, Primary 7, and Secondary 2. Both written and practical forms of assessment were used. Students were also administered a questionnaire to determine student confidence in understanding, preferences in science, and learning activities they might have experienced. The assessment framework was developed to take account of the science component of National Guidelines for Environmental Studies. Five Strands--"Knowledge and Understanding," "Planning, Collecting Evidence," "Recording and Presenting," and "Interpreting and Evaluating"--provided the category headings and a number of subcategories were identified for the purposes of the analysis. Results are divided into chapters by strand. Separate chapters address the results of the practical assessment portion and results of the student questionnaire. Other chapters cover the results of questionnaires sent to schools in the sample requesting information on school policy for learning and teaching science, performance comparisons across three surveys since 1990, and issues and implications. (PVD)

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1996

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Assessment of
Achievement
Programme

AAP Science 1996

A summary report of the fourth survey

THE SCOTTISH OFFICE
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The full report of the project which describes the 1996 survey of performance in science can be obtained from the University of Strathclyde (Jordanhill Campus), Glasgow. This summary of the main findings has been prepared by the project team in consultation with the Scottish Office Education and Industry Department, with a wide audience in mind.

It should be noted that the next survey of achievement in science is planned for 1999. Because of the need to reuse tasks which proved effective in measuring levels of attainment in previous surveys (1987, 1990 and 1993), the number of items used to illustrate points in this report has been strictly limited.

Information about the AAP survey is also contained in the following publications:

> *Feedback* , a resource for teachers with information about pupils' performance at P4, P7 and S2 and examples of assessment tasks
>
> *Noticeboard*, the AAP newsletter which presents information about work in progress, results from the latest survey and general news about the programme.

For further details of these publications, contact the Dissemination Officer, Educational Research Group, TERI, Scottish Office Education and Industry Department, Victoria Quay, Edinburgh EH6 6QQ.
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Introduction

The Assessment of Achievement Programme (AAP) was established by the Scottish Office Education and Industry Department (SOEID) in 1981 to monitor the performance of pupils in Scottish schools in particular areas of the curriculum. Since 1983, there have been regular surveys in three core curricular areas — English language, mathematics and science. The main AAP objectives are to describe national levels of attainment and to provide evidence about changes in these levels over time. The surveys are intended to inform the SOEID, education authorities, teachers and other interested parties about the achievement of pupils and to indicate ways of improving teaching and learning.

The 1996 AAP Science survey

This survey was directed by Rae Stark and Tom Bryce, with Donald Gray and Lynn Ferguson, at the Jordanhill Campus of the University of Strathclyde. The directors were also involved in the three previous science surveys (1987, 1990 and 1993).

Responsibility for drawing samples of schools and pupils lies with the AAP Central Support Unit (CSU) at the Scottish Council for Research in Education (SCRE) in Edinburgh. They advise on technical matters and liaise with participating schools, distribute materials and carry out the statistical analysis of survey data.

The main objectives of the 1996 AAP were:

- to assess what P4, P7 and S2 pupils know and can do in agreed aspects of science
- to relate performance, where possible, to levels in National Guidelines: Environmental Studies 5-14 (science component)
- to provide comparisons, where possible, of performance in 1990, 1993 and 1996
- to provide comparisons of performance across stages
- to compare performance of girls and boys at each stage
- to compare progress from P4 to P7 within the longitudinal sample.

Sampling

Samples of pupils at P4, P7 and S2 were selected to be representative of pupils in all mainstream schools whether education authority, grant-aided or independent. Approximately 6,500 pupils took part with a similar number of boys and girls being assessed on each aspect. Both written and practical forms of assessment were used. All pupils tackled the written component; sub-samples were drawn to undertake the practical component.

This was the first AAP survey to include a longitudinal element: a number of P4 pupils involved in the 1993 survey were included in the 1996 P7 sample.

The assessment framework

The assessment framework was developed to take account of the science component of *National Guidelines for Environmental Studies (ES 5-14)*. The five Strands, *Knowledge and Understanding* (KU), *Planning* (P), *Collecting Evidence* (CE), *Recording and Presenting* (RP) and *Interpreting and Evaluating* (IE), provided the category headings and a number of sub-categories were identified for the purposes of the AAP analysis.

The specific content assessed and the contexts for skills tasks were drawn from the three Attainment Outcomes (AOs): *Living Things and the Processes of Life*, *Energy and Forces* and *Earth and Space*.

1996 Assessment framework

Knowledge and Understanding (KU)

Planning (P)

- P1: Question raising
- P2: Identifying information sources and resources
- P3: Sequencing plans
- P4: Planning for recording and reporting
- P5: Anticipating problems
- P6: Planning for safety and hygiene

Collecting Evidence (CE)

- CE1: Recognising similarities and differences
- CE2: Recognising changes
- CE3: Extracting information
- CE4: Using simple techniques
- CE5: Estimating and measuring
- CE6: Collecting evidence fairly and safely

Recording and Presenting (RP)

- RP1: Recording in a variety of formats
- RP2: Presenting in a variety of formats

Interpreting and Evaluating (IE)

- IE1: Indentifying relationships
- IE2: Evaluating evidence

The assessment materials

The nature of each individual Strand and Target determined how chosen tasks were to be assessed. Written tests were used wherever they were thought to be appropriate — *Knowledge and Understanding* was almost exclusively assessed through written tasks. In other instances practical tests were considered the only reliable and valid strategy. The survey therefore contained a significant practical component as well as written tests.

Each test booklet contained tasks reflecting two or more 5-14 Levels to tap the range of attainment anticipated within each stage assessed. Five written test booklets were developed for each stage and any one pupil tackled two booklets. Two practical circuits were developed, each containing eight stations and any one pupil tackled one circuit. Two practical investigations were used in the survey on a one-to-one basis; each pupil tackled one investigation.

A three-part questionnaire was included for pupils. The first section attempted to determine pupils' confidence in their understanding in a range of topics and to identify their sources of learning. The second sought information on children's preferences for a selection of topics drawn from the three Attainment Outcomes. The third focused on learning activities they might have experienced in school.

Measuring performance

In the 5-14 programme, pupils can be expected to attain the following levels of performance.

Level A — attainable by almost all P1-P3 pupils.

Level B — attainable by some P3 pupils, or even earlier, but certainly by most in P4.

Level C — attainable by most P4-P6 pupils.

Level D — attainable by some P5-P6 pupils, or even earlier, but certainly by most in P7.

Level E — attainable by some P7-S1 pupils but certainly by most in S2.

For the purposes of this report, 'most' pupils has been set at 75 per cent of the sample at any stage. Each task was marked and subsequently analysed to give an index of achievement for 'most pupils'. This equated to the number of sub-tasks correctly completed and was expressed as a score lying between 0 and 1, where 0 indicates no grasp of the 5-14 target and 1 indicates a very secure grasp. Satisfactory attainment of a target was set at 'most pupils' achieving a score of ≥ 0.8 on any individual task.

The Strand *Knowledge and Understanding* differentiates between 'secure' knowledge and 'making steady progress'. At any stage in an individual pupil's development, it is likely that some concepts and principles will be well-established, others may be less secure or even absent. This survey indicates a 'secure grasp' of relevant knowledge by an index score ≥ 0.8 and 'making steady progress' is indicated in scores between 0.35 and 0.8

Table 1 : Modes of assessment

MODE	MATERIALS	TIME ALLOWED
Written	illustrated booklet	P4 - 30 mins (12 tasks per pupil) P7 - 45 mins (20 tasks per pupil) S2 - 60 mins (25 tasks per pupil)
Practical Circuits	apparatus & materials (stations circuits) illustrated booklet	3-4 minutes per station (8 stations per pupil)
Practical Investigations	apparatus & materials (semi-structured tasks) illustrated booklet	P4 - 20 mins (1 task per pupil) P7 - 20 mins (1 task per pupil) S2 - 30 mins (1 task per pupil)

1 Knowledge and understanding

The specific content which pupils should acquire and develop is set out in the three Attainment Outcomes:

AO1 *Understanding Living Things and the Processes of Life;*
AO2 *Understanding Forces and Energy;*
AO3 *Understanding Earth and Space.*

The content statements within each Attainment Outcome are set out in three (st)age related bands: P1-P3 (5-8 years); P4-P6 (8-11 years); and P7-S2 (11-14 years). These statements map out the knowledge which pupils are expected to acquire and also provide the contexts in which a range of practical and process skills can be developed.

For any one stage, the majority of tasks expected pupils to be able to demonstrate 'secure knowledge and understanding' of the relevant concepts. As many tasks were common to more than one stage, comparisons of performance levels across P4, P7 and S2 could be made.

Example 1: Seasons

The Tasks

All tasks for *Knowledge and Understanding* came in two main forms. In the first, boxes had to be ticked or labels selected; in the second pupils were asked to explain an instance of a concept, demonstrating their understanding of the situation. The example *Seasons* is from the second.

This task was developed to assesses a target in the P1 - P3 band from Attainment Outcome 1 *Living Things and the Processes of Life*. It was included in the P4 and P7 written papers and required pupils to demonstrate an understanding of seasonal camouflage.

For most pupils the index of achievement at P4 was 0.52 and at P7 was 0.74. Neither group demonstrated a secure grasp of relevant concepts.

It should be noted that a substantial number of P4 pupils made no response to tasks which required extended responses. The language burden of such tasks may well have depressed performance levels.

Primary 4 Knowledge and Understanding

A total of 33 tasks were included in the P4 written papers. Table 2 (next page) shows the distribution of stage bands, Attainment Outcome and indicates the numbers which showed 'secure grasp' and 'steady progress'.

In order to have attained Level B, in line with 5-14 criteria, most P4 pupils should have demonstrated a secure grasp of P1-P3 statements and be making

Table 2: P4 written tasks

	AO1			AO2			AO3		
	No. of tasks	secure grasp	steady progress	No. of tasks	secure grasp	steady progress	No. of tasks	secure grasp	steady progress
P1-3	7	4	3	3	1	2	8	7	1
P4-6	5	2	2	5	1	4	2	1	1
P7-S2	2	0	2				1	0	1

steady progress on tasks assessing P4-P6 statements. Overall, P4 pupils demonstrated a secure grasp of the relevant knowledge in 12 of the 18 P1-P3 tasks. In the remainder, there was clear evidence of some understanding of the concepts. In the other two stage bands most pupils were making steady progress.

Primary 7 Knowledge and Understanding

A total of 54 tasks assessed Knowledge and Understanding at P7. Table 3 shows the distribution of 'secure grasp' and 'steady progress'.

To attain Level D, most P7 pupils should have demonstrated a secure grasp of the P1-P6 statements and have made steady progress on the tasks assessing P7-S2 statements. Overall, P7 pupils showed a secure grasp of most relevant P1-P3 statements within Attainment Outcomes 1 and 3, *Living Things and the Processes of Life* and *Earth and Space*. In two of the AO2 tasks, *Energy and Forces*, most pupils showed a secure grasp of concepts assessed, but in the other two tasks, one score fell into the category of 'making steady progress' while the other demonstrated little understanding of the concepts.

In tasks tapping P4-P6 statements, a majority showed a secure grasp, with the remainder making steady progress. All but two of the P7-S2 tasks reached the steady progress range, with a few showing a secure grasp.

On this evidence, P7 pupils were close to the cut-off point for a 'secure grasp' on many of the tasks assessing P1-P6 statements and were clearly making progress on the P7-S2 concepts. Significant weaknesses in some tasks prevent the conclusion that P7 pupils have comprehensively attained Level D in this aspect of the 1996 survey.

Table 3: P7 written tasks

	AO1			AO2			AO3		
	No. of tasks	secure grasp	steady progress	No. of tasks	secure grasp	steady progress	No. of tasks	secure grasp	steady progress
P1-3	6	4	2	4	2	1	3	3	0
P4-6	9	5	4	9	6	3	7	4	4
P7-S2	5	2	2	4	0	4	7	2	4

Secondary 2 Knowledge and Understanding

A total of 71 tasks were included in the S2 written papers. Table 4 details the performance levels attained by most pupils.

To attain Level E, S2 pupils should have demonstrated a secure grasp of key features across P1-S2. The scores for tasks drawing on the statements in the P4-P6 band approached or achieved the secure grasp cut-off point of 0.8 in all AO1 tasks and half of the AO2 and AO3 tasks. Figures for the P7-S2 tasks demonstrated a secure grasp of the content on two of the 15 AO1 tasks, four of the 16 AO2 tasks and eight of the 20 AO3 tasks. All but seven of the remainder were within the 'making steady progress' band.

Figures for S2 tasks indicate that most pupils had a secure grasp of the majority of relevant concepts in the P4 P6 band and were making steady progress on the P7-S2 content. One of the two tasks from the P1 - P3 band posed considerable problems for pupils at both P7 and S2. On the evidence of the tasks in the survey the performance of most S2 pupils showed only limited improvement on that of P7 pupils. Performance fell significantly short of the expected Level E.

Comment

These findings represent a good performance for pupils at P4 and a fair performance at P7, given the stage of implementation of the Environmental Studies 5-14 guidelines at the time of the survey. Performance of S2 pupils was poor given the specific science teaching in years 1 and 2 of secondary school.

Table 4: S2 written tasks

	AO1			AO2			AO3		
	No. of tasks	secure grasp	steady progress	No. of tasks	secure grasp	steady progress	No. of tasks	secure grasp	steady progress
P1-3				2	0	1			
P4-6	4	4	0	8	4	4	6	3	3
P7-S2	15	2	12	16	4	8	20	8	10

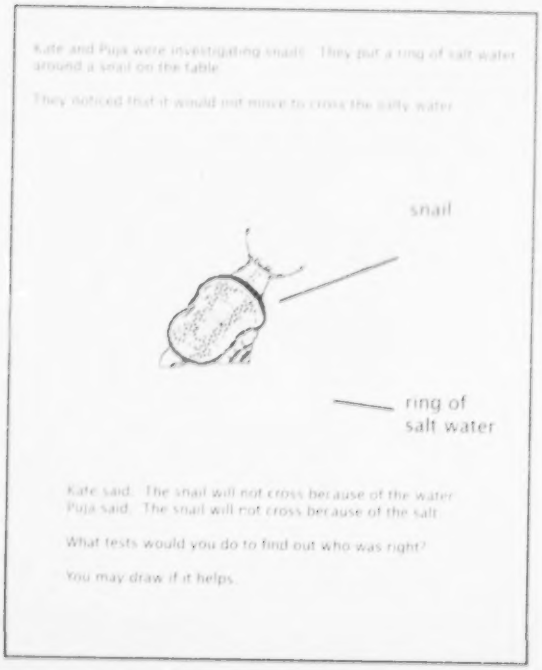
2 Planning

Many of the targets within this Strand are set in a context which AAP cannot readily replicate, therefore only two tasks assessing skills in planning investigations were included in the written component of the 1996 survey. Both had been used in the 1993 written papers and focused on the sub-category P3, *Sequencing Plans*. One task appeared in the P4 test booklets and both were used at P7. No *Planning* tasks were used at S2.

The tasks

The task *Snail Salt* (Level D/E) is an example of the type of task used. In this task, children had to outline a simple investigation to determine which substance, salt or water, inhibited a snail from passing through a ring of salty water. They could respond by either writing about or drawing diagrams of the tests they would make.

Example 2: Snail Salt



The score for most P4 pupils was 0.32. While some pupils were able to identify what should be done to test the two statements, most gave only partial responses.

The score for most P7 pupils was 0.61.

Comment

There were too few tasks to make definitive statements on pupil performance within the ES 5-14 Strand, *Planning*. This area does not readily lend itself to the formats of national monitoring. It is more appropriately assessed by the teacher within the context of ongoing classroom activities, certainly with younger age groups. It is an important area however and one where, drawing on the limited evidence available from these tasks and the Practical Investigations (Section 6), pupils do not seem to have a great deal of experience or expertise.

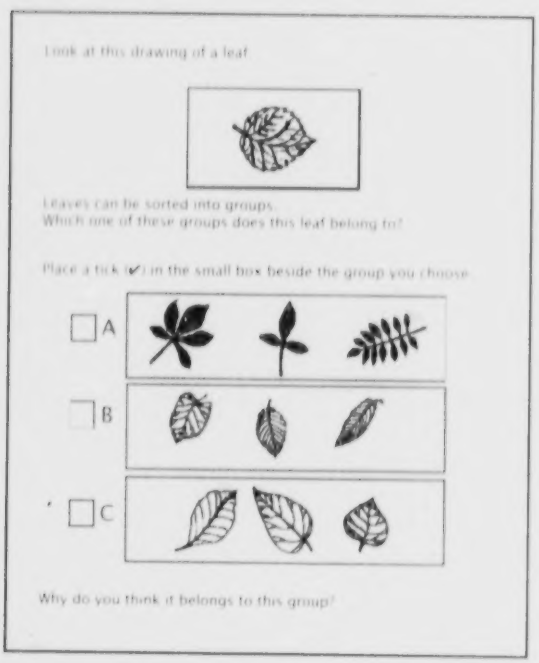
3 Collecting Evidence

Collecting Evidence, which incorporates skills of observing, handling information and investigating, formed the second largest group of tasks in the 1996 survey. Tasks included: *recognising similarities and differences; changes over time; extraction of information from graphical formats; pupils' awareness of how to collect evidence fairly and safely.*

The tasks: written

i. Recognising similarities and differences
Pupils had to look closely at a drawing, match it to one of the groups shown and to provide a reason for their choice. They were given one point for the correct choice of group and an additional point if they gave a satisfactory explanation.

Example 3: Leaves



Most P4 pupils scored 0.57.

Most P7 pupils scored 0.74.

ii. Extracting information
Tasks in this sub-category assessed one aspect of information handling: extracting information from a range of formats. The range of graphical formats assessed was extended at P7 and S2 to include line graphs and diagrams.

Example 4: Garden Pests

Here is a table about garden pests.

Name of pest	What the pest eats	What eats the pest
greenfly	tips and buds	ladybirds
whitefly	leaves	lacewings
beetle grub	roots	birds/moles
leaf miner	leaves	beetles

Use the table to answer these questions.

a. What eats beetle grubs?

b. What eats greenfly?

c. What part of the plant does the whitefly eat?

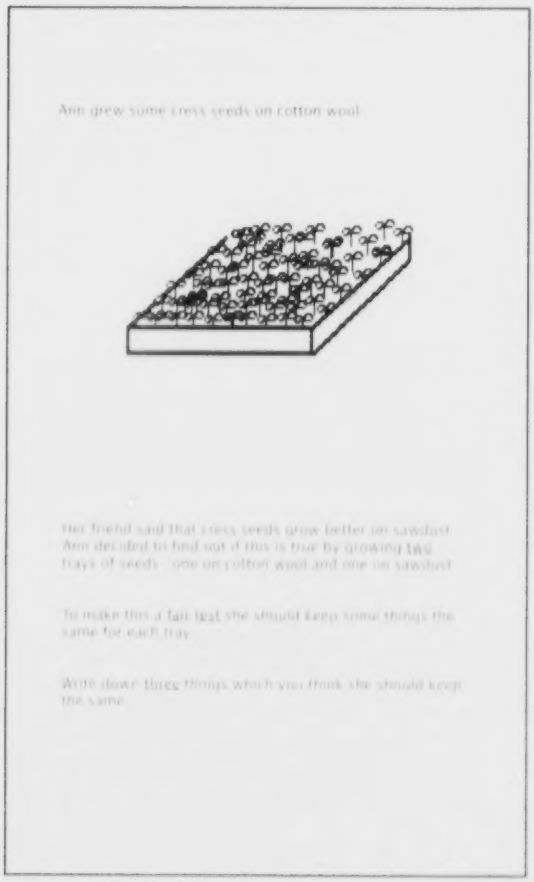
Most P4 pupils scored 0.88, indicating that they experienced little difficulty.

Most P7 pupils scored 0.95.

iii. Collecting Evidence Fairly and Safely

These tasks assessed pupils' understanding of how to undertake practical tasks with attention to safety and hygiene and/or fair testing.

Example 5: Cress



Here pupils were required to identify three aspects of the investigation which should be kept the same to ensure 'fair testing.'

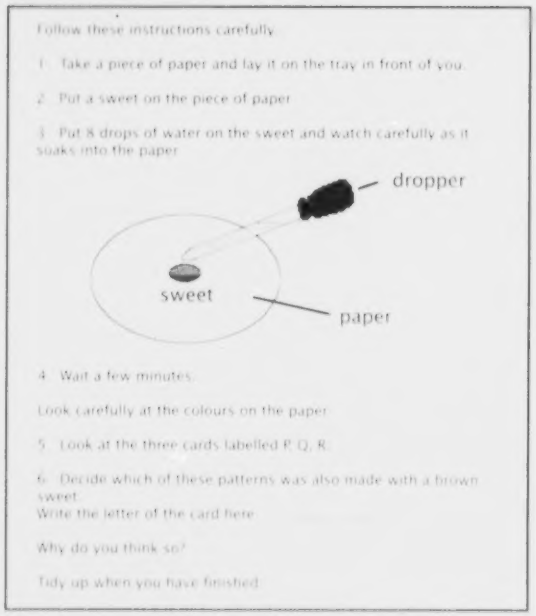
Most P4 pupils scored 0.43. Many pupils had some grasp of 'fair testing' but few were able to give a complete answer to the task.

Most P7 pupils scored 0.73.

The tasks: practical

These tasks focused on observing similarities and differences, changes over time and using simple techniques for 'doing science'. The example *Smartie* assessed pupils' skills in observing similarities and differences as a result of a practical activity (CE1).

Example 6: Smartie



Pupils followed a series of instructions to obtain a simple chromatogram from a sweet. They then had to match their pattern to one of three provided and to justify their decision. A maximum of two points was possible on this task — one for the correct match and one for an acceptable justification.

Most P4 pupils scored 0.67 and most P7 scored 0.78. Many pupils at both stages were able to match the patterns but a smaller number justified the decisions adequately.

Primary 4 Collecting Evidence

A total of 12 written and 13 practical tasks assessed performance on *Collecting Evidence* at P4. Table 5 (overleaf) shows the numbers of these which were 'secure' (i.e. with an index ≥ 0.8 at each Level). The final column shows the mean index score across all the tasks at that Level and the range of scores attained by most pupils.

To meet 5-14 expectations, P4 pupils should have attained at least 0.8 on Level B and be making progress on Level C tasks. While only a small number of tasks reached the 'secure' threshold, the range of scores indicated that most pupils were performing reasonably well on many of the tasks. However examination of individual tasks indicated that main strengths lay in handling information. Performance was relatively weak on 'fair testing' and observing tasks.

Table 5: P4 written and practical tasks

		No. of tasks	No. "secure"	Mean score	Score range
Level B	written	1	1	0.98	
	practical	5	1	0.73	0.69 - 0.83
Level C	written	11	4	0.66	0.43 - 0.96
	practical	8	2	0.69	0.49 - 0.88

Primary 7 Collecting Evidence

A total of 24 written and 13 practical tasks were included at P7.

To meet 5-14 expectations, P7 should have attained at least 0.8 on Level B, C and D tasks and be showing progress on Level E tasks. Mean scores for most P7 pupils indicated that they attained the cut-off score for a secure grasp at Levels B and C. However, a lower number met this criterion for the written tasks at Level C. As at P4, 'fair testing' and observing were the weakest areas. Level D performance did not meet expectations although all but one of the tasks (0.44) were within an acceptable range. Performance on Level E tasks was satisfactory.

Table 6: P7 written and practical tasks

		No. of tasks	No. "secure"	Mean score	Score range
Level B	practical	5	5	0.85	0.81 - 0.96
Level C	written	15	8	0.81	0.59 - 0.99
	practical	8	6	0.86	0.78 - 0.95
Level D	written	5	2	0.70	0.44 - 0.84
Level E	written	4	2	0.69	0.33 - 0.93

Secondary 2 Collecting Evidence

A total of 38 tasks were used at S2, 24 written and 14 practical.

To meet 5-14 expectations, S2 pupils should have attained 0.8 at all Levels. All mean scores reached the cut-off figure and, overall, pupils demonstrated a secure grasp of the majority of the tasks. Performance on a few tasks was less than satisfactory and again these tended to be those assessing the observing and 'fair testing' statements.

Comment

Performance was good at S2 with pupils operating at close to the expected 5-14 Level. P4 and P7 were not yet secure at the relevant Levels with considerable variation in performance on tasks. The more traditional 'handling information' tasks were successfully tackled at all three stages and in line with 5-14 expectations.

Such skills can be assessed by written tests, which have been a feature of all four science surveys to date, but practical contexts should also be used to ensure validity of the assessment. Requisite skills are best acquired and developed through practical activities which are purposeful and demand an integration of skills, processes and conceptual understanding.

Table 7: S2 written and practical tasks

		No. of tasks	No. "secure"	Mean score	Score range
Level B	practical	2	1	0.87	0.72 - 0.83
Level C	written	12	11	0.88	0.61 - 0.98
	practical	9	7	0.84	0.53 - 0.97
Level D	written	5	4	0.82	0.55 - 0.92
	practical	3	3	0.87	0.80 - 0.98
Level E	written	7	6	0.81	0.61 - 0.93

4 Recording and Presenting

This Strand contains two broad groups of statements, only one of which — recording in a variety of formats — was assessed in the survey. The second group — including oral presentations, personal topic folders and displays — was not appropriate to assessment in national monitoring exercises. The number of tasks representing this Strand was relatively small and findings should be considered alongside those of the AAP Mathematics surveys.

Table 9: Number of written and practical RP1 tasks by stage

	P4		P7		S2	
	Written	Practical	Written	Practical	Written	Practical
RP1	5	2	4	2	8	2

The tasks: written

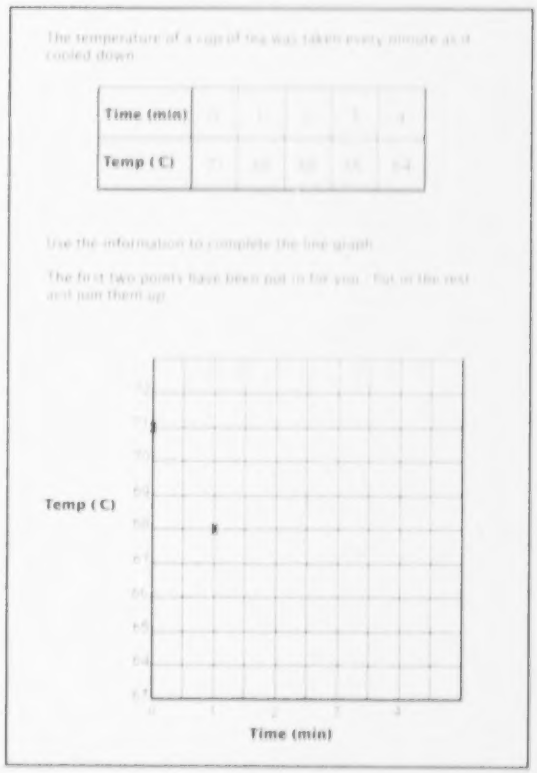
At the primary stages, most of the tasks required pupils to complete tables and graphs of different kinds using the information given. The range of formats was extended to include line graphs for P7 and S2. Example 7 *Teacup* was common to both stages and the inclusion of a line graph sets the task at Level D. The ES 5-14 guidelines expect pupils to provide their own labels and axes.

Assessment was based on of accuracy of points, correct format (line), and appropriate form of line to join the points (curve or series of short lines).

Most P7 pupils scored 0.58 — the relatively low score can be attributed partly to the tendency to join points in a series of short lines rather than an appropriate curve.

Most S2 scored 0.76.

Example 7: Teacup



The tasks: practical

Primary pupils were asked to sort objects into groups and to complete a table and a graph to show the number in each group as in Example 8 (over).

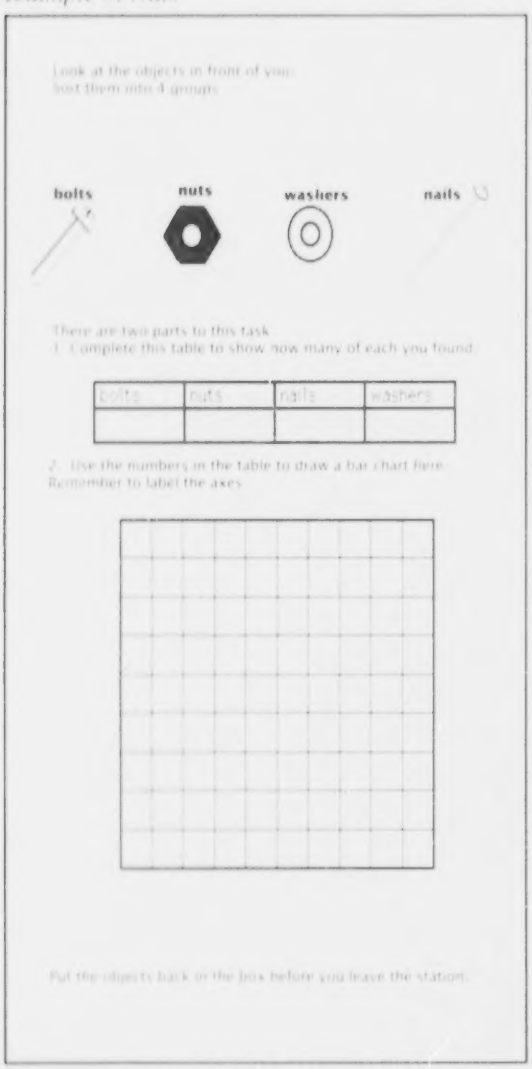
Pupils had to count the different types of nuts, bolts etc. and to construct a bar graph to display their findings.

Most P4 pupils scored 0.75.
Most P7 pupils scored 0.92.

The two S2 practical tasks assessed aspects of 'drawing diagrams using conventional symbols' which were considered inappropriate for earlier

stages. In one task, pupils had to construct a circuit from a drawing and then draw the circuit diagram. In the second, they filtered muddy water and, while the mixture was trickling through, drew a diagram of the assembled apparatus. In each case, the diagram was the focus of assessment within this category. Both tasks were Level E.

Example 8: Nuts



Primary 4 Recording and Presenting

There were a total of seven *Recording and Presenting* tasks, five written and two practical.

To meet 5-14 expectations, P4 pupils should have reached 0.8 on Level B tasks and shown some grasp of Level C tasks. Most pupils met the criteria but the limited number of tasks on this Strand makes it difficult to draw overall conclusions.

Table 10: P4 summary performance

		No. of tasks	No. "secure"	Mean score	Score range
Level B	written	2	2	0.95	0.94 - 0.95
Level C	written	2	1	0.87	0.79 - 0.95
Level D	written	1	0	0.44	
	practical	2	0	0.70	0.64 - 0.75

Primary 7 Recording and Presenting

A total of six tasks, three written and three practical, were included.

Table 11 : P7 summary performance

		No. of tasks	No. "secure"	Mean score	Score range
Level B	practical	1	1	0.93	
Level C	written	2	2	0.92	0.87 - 0.98
Level D	written	1	0	0.58	
	practical	2	2	0.87	both 0.87

To meet 5-14 expectations, P7 pupils should have reached at least 0.8 on tasks at and below Level D. This they did on five of the six tasks (one Level D task involving a line graph, *Teacup*, failed to reach 0.8).

Secondary 2 Recording and Presenting

A total of ten tasks, eight written and two practical, were included at S2.

Table 12: S2 summary performance

		No. of tasks	No. "secure"	Mean score	Score range
Level C	written	2	2	0.92	0.86 - 0.98
Level D	written	5	2	0.79	0.64 - 0.95
Level E	written	1	0	0.45	
	practical	2	0	0.58	

To meet 5-14 expectations, S2 pupils should have attained ≥ 0.8 on all tasks set. While they did reasonably well with handling information in tables and graphs, S2 did not perform well on tasks which drew on knowledge of the conventional symbols and diagrams used in science. Both P7 and S2 pupils showed uncertainty in tasks involving line graphs.

Comment

Tasks tended to focus on inserting given information into tables, graphs etc. and were successfully completed by most pupils. In most respects performance at P4 and P7 was close to expected 5-14 Levels. S2 pupils did not reach the expected Level. Where the task contained a line graph, performance levels did not meet expectations (P7 and S2 pupils only). S2 pupils also performed poorly on tasks which might be expected in the production of an investigation report: drawing the apparatus and instruments they used in practical contexts.

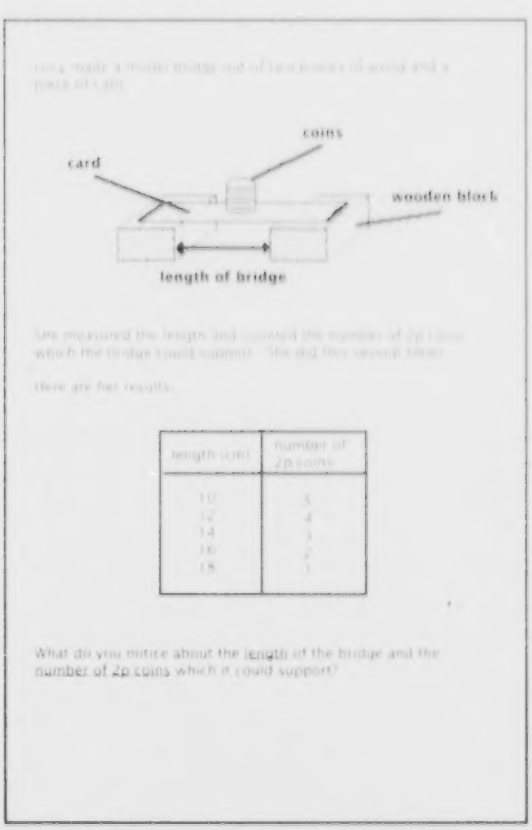
5 Interpreting and Evaluating

The 5-14 Strand *Interpreting and Evaluating* had two sub-categories. Tasks from the first, *Assigning Meaning*, assessed targets such as identifying relationships, explaining, forming generalisations, drawing conclusions and predicting. Tasks from the second, *Evaluating Evidence*, focused on distinguishing between inferences and observations.

The tasks: written

In the four tasks from the first sub-category, pupils were required to identify a relationship, pattern or trend from information presented in a graphical form.

Example 9 : Bridgespan



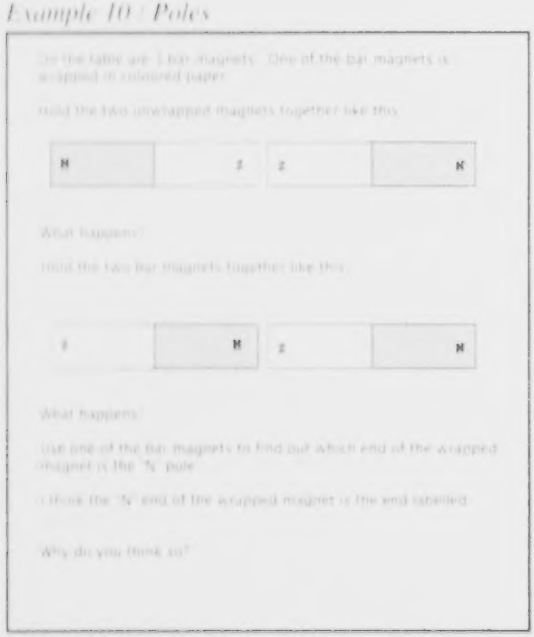
This Level B task asked pupils to identify an inverse relationship — 'the longer the bridge, the fewer coins it can support'.

Most P4 pupils scored 0.38 and most P7 pupils scored 0.58.
Most S2 pupils did significantly better with a score of 0.84

The tasks: practical

The task *Poles* was included in the practical circuits at Level D for P7 and S2 pupils.

Example 10 : Poles



In the first part of this task, pupils had to note what happened as two magnets were placed as specified. In the second part they had to use the evidence to determine the correct pole of a third, covered, magnet.

Most P7 pupils scored 0.68, most S2 pupils 0.76.

Primary 4 Interpreting and Evaluating

Twelve tasks, nine written and three practical were included in the P4 assessment materials. Table summarises performance levels.

Table 14 : P4 performance summary

		No. of tasks	No. "secure"	Mean score	Score range
Level B	written	4	0	0.52	0.38 - 0.64
Level C	written	5	0	0.53	0.47 - 0.61
	practical	3	0	0.56	0.50 - 0.68

To meet 5-14 expectations for P4, the index scores for all Level B tasks should reach 0.8 or above and show some grasp at higher levels. P4 pupils did not quite attain scores consistent with Level B although they did show some understanding and skill in a majority of the tasks tackled. As in previous surveys, a significant number of P4 pupils made no attempt at questions requiring extended responses.

Primary 7 Interpreting and Evaluating

Twenty tasks were included, 16 written and four practical.

Table 15 : P7 summary performance

		No. of tasks	No. "secure"	Mean score	Score range
Level B	written	3	1	0.70	0.58 - 0.84
Level C	written	10	1	0.66	0.48 - 0.80
	practical	3	1	0.71	0.65 - 0.80
Level D	written	3	0	0.42	0.29 - 0.45
	practical	1	0	0.68	

To meet 5-14 expectations, most pupils should have reached 0.8 for all tasks at the Levels to D and show a degree of competence on those at Level E. Overall, P7 pupils did not achieve the Level D expectations.

Secondary 2 Interpreting and Evaluating

Twenty-four tasks were included at S2: 20 written and four practical. Table 16 summarises the findings.

Table 16: S2 summary performance

		No. of tasks	No. "secure"	Mean score	Score range
Level B	written	2	2	0.84	both 0.84
Level C	written	8	0	0.65	0.53 - 0.78
	practical	3	1	0.73	0.69 - 0.80
Level D	written	10	0	0.62	0.36 - 0.77
	practical	1	0	0.76	

In order to meet ES 5-14 expectations, S2 pupils should have attained 0.8 on all tasks in the survey. Most pupils achieved this on Level B tasks, and all but one of the Level C scores were in the 0.6-0.7 range. Performance on Level D tasks was very varied but never reached 0.8.

Comment

Tasks in this Strand required pupils to identify relationships in data and to evaluate evidence from a variety of sources. At no stage did pupils produce scores which could be said to have met the appropriate 5-14 Levels. As in previous surveys, there was clear evidence that pupils could extract specific pieces of information from a range of formats and add information to tables, graphs etc. but could not interpret the messages conveyed by data presented in these formats.

In evaluating evidence and sorting observations from inferences, pupils again were operating below the Levels which were expected of them. As in all three previous AAP Science surveys, they 'jumped to conclusions' by selecting likely explanations without considering whether the evidence justified the inference(s).

6 Practical Investigations

While the assessment of individual Strands and Targets provides useful information on what children know and can do in aspects of science, it is when they try to integrate the various knowledge and skill bases in the context of extended investigations that they reflect the demands of 'doing science'.

The tasks

There were two investigations, *Race Track* and *Rising Damp*. The first was based on motion down an inclined plane, the second was concerned with the rate at which liquids rise through different grades of paper. These were relatively closed investigations where pupils were presented with a specific question to answer which required them to work with practical apparatus, to gather evidence and, on the basis of that evidence, reach a conclusion.

Primary 4

P4 pupils performed better on *Race Track* than *Rising Damp*. The purpose of *Rising Damp* and the specific content appears to have been less accessible and relevant to them. Approximately 66 per cent of pupils in the sample displayed a satisfactory level of manipulative skills. While many pupils did undertake fair tests on *Race Track*, this appeared to be by good fortune rather than design. The variables to be controlled in *Rising Damp* were less obvious and only around 25 per cent of P4 pupils made 'fair tests' of the conditions in this investigation. P4 pupils appeared, both in tackling the investigation and during the probing at the end, unaware of the need to take deliberate steps to ensure fair tests.

As in previous years, very few pupils recorded results. Virtually all came to a conclusion at the end of the investigation, although some had been carried out so haphazardly that no conclusion was justified. Only a small proportion acknowledged this when given the opportunity to reflect critically upon the activity and suggest changes.

Primary 7

Virtually all pupils appeared to understand the task initially and the majority proceeded in a systematic manner to test the cars in *Race Track* and grades of paper in *Rising Damp*.

It is difficult to interpret the low percentage of pupils judged to be satisfactory in handling the apparatus/instruments on *Race Track* although it may be due to the Field Officers holding higher expectations of the P7 pupils on the same task and finding them wanting. (The same field officers assessed P4 and P7 but not S2.)

As at P4, those tackling *Race Track* were much more successful in controlling for fair tests than those on *Rising Damp*. Similarly, the majority recorded results in *Race Track*, and far fewer did in *Rising Damp*. Half of the pupils acknowledged that there were ways in which the method used could be improved.

Secondary 2

Almost all S2 pupils understood *Race Track* and proceeded in a systematic way to test the conditions. While most pupils understood the purpose of *Rising Damp*, a substantially smaller percentage undertook a systematic investigation.

On *Race Track*, the majority of pupils controlled the relevant variables in a deliberate, systematic way, measured accurately the distance the block travelled and recorded the results on the pupil booklet. They drew valid conclusions and appeared aware of how such investigations should be conducted.

In contrast, while almost all appeared to understand

what was required in *Rising Damp*, around 67 per cent controlled potentially confounding variables and just under 50 per cent made accurate measurements of the dependent variable.

Approximately 75 per cent recorded the results of their tests and most reached a conclusion on the grade of paper through which the water rose more quickly.

Given the opportunity to reflect, between 40 per cent and 50 per cent of those working on *Rising Damp* made relevant suggestions for improvements, suggesting that they were aware of deficiencies in the approach taken.

Comment

It should be noted that the experiences of the team and feedback from Field Officers indicated that a significant proportion of pupils at all three stages, but more in particularly the primary sector, were unfamiliar with practical activities in science. However, the pupils set to the tasks readily and demonstrated considerable learning in the course of the investigation. This is reflected in the nature of the many suggestions which they made for improvement, indicating that their participation had been as much a learning experience as an opportunity to demonstrate acquired knowledge and skills.

Until such extended practical activities, in a range of formats, become a commonplace part of science learning and teaching in schools, assessment of integrated tasks such as these can only indicate general patterns of performance in broad categories of knowledge and skill.

7 Pupils' Views on Learning Science

The questionnaire to pupils had three sections. The first asked P4, P7 and S2 pupils how confident they felt about their own knowledge in a number of topic areas and to identify the main source of that learning. The second asked them to show their preference for studying different topics in science and the third sought information on the frequency with which they experienced a range of activities in the science classroom and how much they enjoyed these. The last section was only set at P7 and S2.

Scientific knowledge and sources of learning

At all three stages, pupils were most confident in their understanding of topics which drew on the key features of AO1: *Living Things and the Processes of Life*. Generally speaking, P4 pupils were more confident in their own scientific knowledge than those in the older groups. The figures may be a reflection of the content provided at different stages of primary and early secondary school and, if so, this would indicate that topics from AO2: *Energy and Forces* and AO3: *Earth and Space* are only really contributing to pupils' understanding in the upper primary and early secondary years.

A worrying feature is the growing emphasis on the school as a key source of scientific knowledge as pupils progress from P4 to S2, at the expense of other sources, in the views of pupils. Other key sources such as parents, television, museums and books diminish as children grow older, according to their stated judgements. When pupils leave school their main source of information is closed and other sources have gone into disuse. This does not bode well for the notion of a scientifically literate population.

Favourite topics in science

When pupils were asked to rank their preference for a number of topics in science, boys and girls demonstrated different patterns of response. Firstly, whatever the age group, the girls were much more in agreement in their choices than were the boys. Secondly, the pattern of preferences amongst P4 girls was not greatly different from that given by the P7 and the S2 girls; the boys' preferences were more varied and showed a clear shift in their preferences from the biological sciences at P4 to the physical sciences at S2.

Learning activities in science

Only P7 and S2 pupils were involved in this section of the questionnaire and their responses corresponded well with the (less detailed) reports from schools. In particular, there was evidence of a greater emphasis on whole class teaching in secondary schools than in the primary sector.

Both samples of pupils reported that they rarely had the opportunity to follow up their own questions in school and that teacher explanations/demonstrations were amongst the more frequent forms of activity. Patterns of preference were similar in P7 and S2, with problem solving, the use of apparatus and watching television/video programmes amongst the more popular activities.

In general, both boys and girls were more positive than negative in their responses although at P7 there was some evidence that boys were more polarised in their views of science activities, i.e. either positive or negative, whereas girls were more likely to remain neutral.

Comment

At all three stages, pupils expressed the greatest confidence in AO1: *Living Things and the Processes of Life* although the gap between the Attainment Outcomes narrowed in P7 and again in S2, possibly a result of the increased teaching focus on physics and chemistry topics as pupils get older.

S2 pupils are heavily dependent on the school as their main source of information about science topics and concepts. Alternative information routes do not seem to be well established to sustain interest and knowledge when pupils leave school, or give up science.

The opportunity to follow up their own investigations in class appears more likely to be afforded to S2 pupils than P7 pupils.

8 Information from Schools

Questionnaires were sent to every school in the sample (96 secondary and 215 primary) requesting general background information on each school's policy for the learning and teaching of science at the stages concerned. In addition, information was sought on the materials and approaches used and teachers' views on the important aspects of science teaching.

A policy for science

Just over half of the primary schools reported that they did have a policy for science while approximately one third said that they did not. (The 1993 figures were very similar.) In primary schools, where there was a policy it tended to be one where science was an integral part of environmental studies. A small, but growing, percentage of schools regarded science as the main focus for topic study or as a subject in its own right. Most secondary schools reported that science was taught as 'integrated science' in S2 while around one fifth said that it was taught as 'separate sciences'.

Only half of the primary schools and an even smaller proportion of secondary schools stated that the policy reflected the 5-14 Environmental Studies guidelines.

9 Learning and Teaching Science

Primary Schools

The 5-14 guidelines imply that around 7.5 per cent of class time should be devoted to science.

In approximately 30 per cent of primary schools surveyed, 5 per cent to 10 per cent of the timetable was reported to be allocated to science. A very small number allocated more than this, with the remainder giving < 5 per cent. This represents a noticeable increase in the proportion of primary schools allocating between 5 per cent and 10 per cent of the time to science since 1993. This can probably be attributed, at least in part, to the influence of the ES 5-14 guidelines. However, approximately 40 per cent of primary schools are allocating less than the recommended time.

Primary teachers identified pressure of time as the biggest obstacle to increasing the time allocated to science. Lack of resources and lack of accommodation were also significant problems; only 26 per cent of schools reported being 'well equipped' with practical or commercial materials.

Compared with 1993, fewer regarded teachers' attitudes/qualifications etc. as a barrier to increased provision (36 per cent in 1996; 70 per cent in 1993). However, the evidence suggests that there is still some way to go in providing adequate support for teachers in implementing science in line with ES 5-14. A substantial number of teachers reported no in-service or P.A.T. provision for science and only 21 per cent indicated that support was provided by other means.

Secondary Schools

The 5-14 guidelines recommend a minimum allocation of 10 per cent (approximately 2 hours 40 minutes) to science in the secondary school; 99 per cent of schools are providing a time close to or in excess of this recommendation.

There were clear differences in the way teaching and learning was organised in primary and secondary classes. In primary schools there was more emphasis on group-based working than whole- class teaching. In secondaries, although many teachers reported using group work and/or individualised learning, there was more emphasis on whole-class teaching than in primary schools.

Assessment was carried out frequently in almost all schools and most often by the 'end of topic test'. Assessment appears to be used primarily for summative purposes; no school reported the use of assessment for specifically diagnostic purposes.

In both primary and secondary sectors the emphasis on understanding of basic science concepts has increased since the previous survey. In the 1993 primary sample, just under half opted for this goal whereas almost three quarters did so in 1996. In secondaries the corresponding figures were significantly higher in both surveys.

Comment

The 5-14 Environmental Studies guidelines do appear to have had an influence on practice, but there is still some way to go before they are fully operational in all schools, particularly in the primary sector. This may be a reflection of structural differences in primary and secondary, with primaries having to prioritise developments and phase in changes over a longer period.

While the specific learning goals selected were similar to previous surveys in both primary and secondary sectors, there was an increased emphasis on 'understanding of basic science concepts' in both. This may well be, at least in part, due to the influence of the ES 5 - 14 document.

The feedback from schools indicates that, overall, there has been some change in policy and practice ot be said to reflect the full implementation of the guidelines on science and rather should be considered as baseline measures of attainment against which performance in future surveys can be compared.

10 Performance Comparisons

Performance over time

Across the three surveys since 1990:

- P4 performance has risen on written but not on practical tasks
- P7 performance has remained fairly steady on both components
- S2 performance has fallen somewhat on written tasks although the position is less clear with regard to practical tasks.

The 1993-96 data was analysed to determine whether these changes were related to gender. At P4, all significant differences between 1993 and 1996 were in a positive direction, with marginally greater improvement shown by girls, across the common tasks. At P7, positive changes considerably outweighed negative ones, with little difference between the performance levels of boys and girls. The pattern was reversed however at S2 where the majority of significant differences point to a decline in performance marginally greater for boys than girls.

Performance between stages

Pupils at P7 and S2 stages produced performances significantly superior to those at P4 on all of the common tasks. Comparisons of the P7 and S2 performance levels are less clear cut, with the older group producing significantly better success rates than P7 on 67 per cent of the common written tasks and 56 per cent of the practical ones.

These patterns are in line with those of earlier surveys, indicating that while pupils appear to make significant developments in the knowledge, skills and processes assessed across the P4 to P7 stages, the difference in performance from P7 to S2 does not appear to reflect the two years of specialist science teaching which they have experienced.

In the longitudinal study which followed a sub-sample of P4 pupils from 1993 through to 1996, the main findings indicate that, generally, those pupils who performed above average in 1993 continued to do so in 1996, with a slight indication of an increasing gap between the high and low achievers from P4 to P7.

11 Issues and Implications

The main findings and the implications for the learning, teaching and assessment of science in the primary and early secondary stages are as follows.

i. Performance in 1996

The main conclusions are that:

- performance levels were good at P4 and fair at P7, although specific Key Features and Strands showed signs of weakness
- performance levels at S2 gave cause for concern across all aspects tested, except perhaps handling information
- the two younger groups had improved or maintained performance levels while S2 pupils showed a slight decline
- differences in performance levels between pupils P7 and S2 gave concern over learning and teaching in the first two years of secondary school
- gender differences in performance levels along traditional lines were evident, with implications for teaching, learning and assessment
- a generally positive attitude to science was indicated at all stages, though this tended to wane as pupils progressed through school.

ii. Policy and Provision

The main messages are that:

- ES 5-14 guidelines on science are beginning to make their presence felt, at least in primary schools. Progress is slow however.
- Obstacles to effective implementation — not least time and resources — have been identified by teachers.
- Staff development opportunities are required both locally and nationally.
- Teachers place increasing emphasis on knowledge and understanding in science teaching and learning.
- Opportunities for 'hands on' science are relatively rare although pupils indicate this is a particularly enjoyable aspect of school science.
- The poor performance of S2 pupils in 1996, and its decline over time, indicates the need for a major review of the teaching and learning of science in the first two years of secondary school.